

A MILK UREA MODEL TO BETTER ASSESS NITROGEN EXCRETION AND FEEDING PRACTICE IN DAIRY SYSTEMS

Edouard, N.¹, Dumercy, L.², Brun-Lafleur, L.², Rouille, B.², Faverdin, P.¹

¹ PEGASE, INRA, Agrocampus-Ouest, Rennes, France; ² Institut de l'élevage Service Productions laitières, Paris, France

INTRODUCTION

Agricultural systems are facing increasing demands to reduce their environmental impacts. In particular, livestock is the main source of ammonia emissions causing damages on air, water and animal and human health. This ammonia comes essentially from the volatilization of the nitrogen (N) excreted in the urine, especially in the form of urea (Monteny and Erisman, 1998). One of the important levers to reduce the amount of N excreted is the feeding of animals. However, fine management of nitrogen nutrition requires working with simple and inexpensive indicators that are robust and reliable enough to estimate excretion and allow rapid correction of diets. In dairy systems, milk urea, nowadays routinely accessible by infra-red spectrophotometry, is undoubtedly the best biological indicator for quantifying N metabolism losses (Burgos et al., 2007). An objective of our research project is to build models and tools, tested in real-life situations, to better interpret this indicator both at the dairy herd level to evaluate the practice of nitrogen rationing and at more aggregated scales to assess the impacts of feeding practices on the environment.

First, a model was built to represent the dynamics of the main N component flows in the dairy cow. Second, simplified meta-models were proposed to predict diet N content and N excretion from a small number of parameters such as milk urea and additional information on the diet. These meta-models will be available to improve current evaluation and decision support tools both for public policies and advisors on farm.

MATERIAL AND METHODS

The model

The mechanistic model of N flows at the individual level was designed to use feed and animal performance information, among those often available in livestock farms, as inputs. It predicts N excretion, especially through urine, both in the form of urea-N and non-urea-N. The analysis of the model was performed by comparison of its outputs with databases derived from experimental tests or simulations and by the use of sensitivity analyses.

Meta-models

Meta-models resulted from the analysis of one million animal-diet combination simulations (SYSTALI model; INRA, 2018) to associate feed input and milk output. They consisted in simplified equations to predict diet N content and N excretion from milk urea and some additional information on the diet, available on farm. These equations were validated by comparison with datasets of experimental measurements and confronted with data from commercial farms in various French contexts.

RESULTS AND DISCUSSION

The model

The inputs of the model describe the animal and its diet including the way it is distributed. The cow is characterized by its milk yield, milk nitrogen content, body weight and body condition. The diet is defined by its components (forage, concentrates), nitrogen content and dry matter intake. The intake dynamics is also simulated regarding diet distribution modalities. Figure 1 describes the simulation of N flows for a cow fed with maize silage. Outputs of the model showed good correlations with experimental data (e.g.: slope of the observed vs. predicted uremia = 0.9, RMSE = 29 mg urea-N/L).

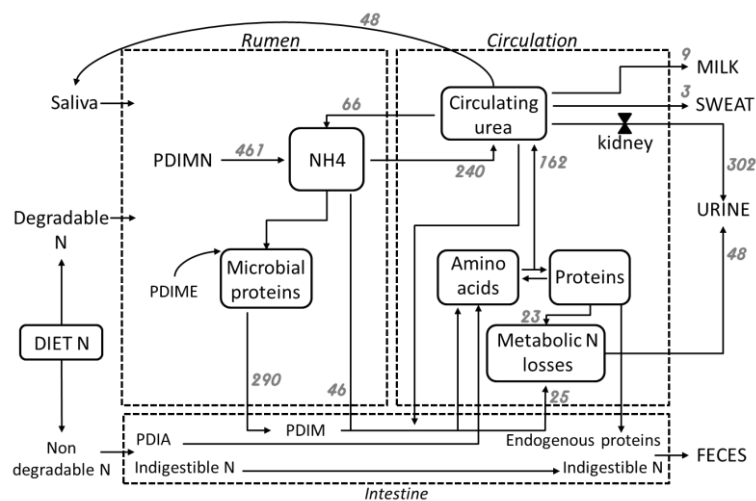


Figure 1. Main nitrogen flows, in g/day, as simulated by the model for a multiparous dairy cow fed with maize silage and producing 40L of milk per day. PDI: protein digestible in the intestine, PDIMN: PDI supplied by microbial protein from rumen-degraded dietary nitrogen, PDIME: PDI supplied by microbial protein from rumen-fermented organic matter, PDIA: PDI supplied by rumen-undegraded dietary protein (Inra, 2007)

Meta-models

Urinary total-N and urea-N were well predicted from simplified equations using milk urea, milk nitrogen content, milk yield and the proportion of concentrates in the diet as predictive variables ($R^2 = 0.99$, RSME = 10 and 5 gN/d for urinary total-N and urea-N respectively). The same variables were also showed to be good, but less precise, predictors of the N content of the diet when associated with urinary total-N or urea-N excretion ($R^2=0.95$, RMSE = 6 g/kgMS). However, this last variable is rarely available on farm and has therefore to be estimated from the model (or simplified equations).

CONCLUSION

Confrontation with experimental data showed that the model correctly describes N flows at the animal level. The resulting meta-models still need to be evaluated with real-life data but seem to quite efficiently predict both nitrogen excretion and diet content. It will therefore be possible to mobilize these estimations to better integrate changes in feeding practices for national inventories (collaboration with CITEPA) and to elaborate decision-support tools for farmers and their advisors to better manage nitrogen nutrition.

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REFERENCES

- Burgos S. A., et al., 2007. Prediction of ammonia emission from dairy cattle manure based on milk urea nitrogen: Relation of milk urea nitrogen to urine urea nitrogen excretion. *J. Dairy Sci.*, 90, 5499-5508.
- Inra. 2007. Alimentation des bovins, ovins et caprins - Besoins des animaux - Valeur des aliments - Tables INRA 2007. Quae.
- Inra. 2018. INRA feeding system for ruminants. Wageningen Academic Publishers, Wageningen, the Netherlands, 640 pp.
- Monteny G. J., Erismann J. W. 1998. Ammonia emission from dairy cow buildings: A review of measurement techniques, influencing factors and possibilities for reduction. *Neth. J. Agric. Sci.*, 46, 225-247.